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ABSTRACT

Computer Assisted Design (CAD) and Computer Assisted Manufacturing (CAM) are emerging technologies now being used in home economics and interior design applications. A microcomputer in a computer network system is capable of executing computer graphic functions such as three-dimensional modeling, as well as utilizing office automation packages to perform nongraphic functions such as cost analysis and word processing. The design process can be divided into four stages: evaluation of the site, personnel, economics, and intentions of the client; planning; graphic and nongraphic representation of the problem; and facilities management. Interior designers can advance the use of CAD technology by using the technology themselves, conducting research on the use of the technology, and developing a relationship between higher education and industry. Home economists are a valuable resource in the development of computerized systems and continuing education for their users. (13 references) (DB)

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Computer Applications in the Design Process

by

Susan Winchip

Paper presented at the Association for the Development of Computer-Based Instructional Systems, November, 1990.

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COMPUTER APPLICATIONS IN THE DESIGN PROCESS

A goal of the Electronic Technology Committee of the American Home Economics Association (AHEA) is, "to enhance communication and interaction of Home Economists concerned and interested in application and use of electronic technology." Computer applications in the design process are rapidly increasing to effectively and efficiently serve the needs of interior designers Computer utilization enhances and supports the way in which designers work, but it has not changed the design process itself. The increasing application and use of electronic technology in the design process has the potential to enhance the creative (1), as well as the technical attributes of design.

Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) is an emerging technology that is now being used by all aspects of the design and manufacturing process, with the potential to be transferred to other Home Economics disciplines in the future. Both industry and higher education are engaged in the training of large numbers of designers in the fundamentals and advanced concepts of CAD/CAM. In the future, a lower cost of training is expected for high schools and vocational schools with less expensive microcomputer-based CAD/CAM systems. When the less expensive CAD/CAM systems are available, the issues of cost, training, and software/hardware specification should be explored. However, until

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this time, it is necessary to keep Home Economists abreast of technological advancements in order to prepare for the emerging applications in the field of Home Economics. Thus, the intent of this article is to address the computer applications in the design process and explore the contributions of a unique emerging technology to the field of Home Economics, so that discussions on the impact of the computer in the profession can occur with an increased awareness.

Design Process

The design process can be divided into four stages (figure 1). The first stage in the design process is the establishment of a project; including evaluation of the site, personnel, economics and intentions of the client. The second stage is the formulation of a plan for approaching the solution with schematic designs. The ultimate solution may depend heavily on the process involved with these sketches. The third stage is an attempt to create a realization of the problem through graphic and nongraphic functions. In the fourth stage project administration is performed by facilities management. Facilities management consists of contract document production and designer-owner-contractor communications. This stage can be an ongoing process for numerous years.

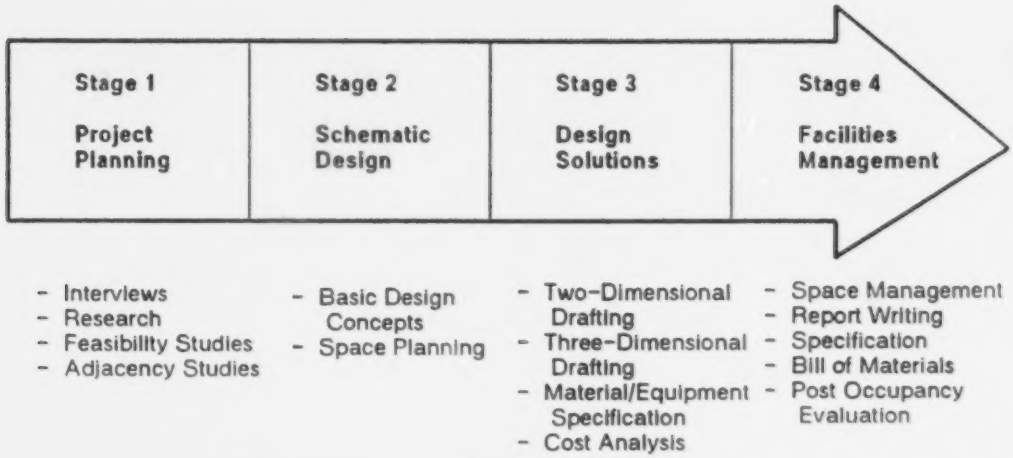

Figure 1. Diagram of the Design Process

A design project proceeds by the performance of various graphic and nongraphic functions. Automation of a procedure for performing a function can improve accuracy, quality, and reduce the time taken to complete a project. As outputs from various procedures accumulate an extensive project data base is created. This information in the data base can be divided into two categories: temporary and permanent working data. Notes and schematics are in the temporary data category. Permanent working data consists of drawings, specifications, catalogues of manufacturers products, and libraries of standard design details (2). Project data bases require consistency and frequent updating and correction to assure accuracy.

Designers are required to perform various graphic and nongraphic functions that can utilize Computer-Aided Design and Drafting (CADD), including:

- Determining feasibility and program requirements;
- Designing schematics and layouts;
- Planning space;
- Presenting plans, elevations, sections, and perspectives;
- Analyzing cost of projects;
- Generating schedules, specifications, and precedence diagrams; and
- Managing projects.

Design procedures are usually labor-intensive, however, an alternative to manual performance is to employ a computer system (Figure 2) integrated with the appropriate software. A CADD system can produce higher quality results at a lower cost and higher speed. It is not feasible to automate all design functions, but there is an extensive range of cost-effective graphic and nongraphic applications.

Graphic Applications

Many designers implement CADD using two-dimensional (2-D) software because it produces the same spatial cognition as drawing on paper. The only difference is in the tool that is used. A CADD system simply display's a designer's drawing on a graphics monitor. All of the additions and changes that occur during a session appear on the monitor. This monitor takes the place of paper, T-squares and triangles used in traditional drafting techniques. Two dimensional software enables a designer to draw floor plans, elevations, and construction details with improved quality, productivity, and accuracy.

Three-dimensional (3-D) software allows a designer to study a X, Y, and Z coordinate model by exploring visual/spatial relationships and to analyze proposed changes to a structure (3). Three-dimensional models allow an infinite number of perspectives of an object or structure to be examined and their interrelationships associated with the design process (4). Even the simplest wire-

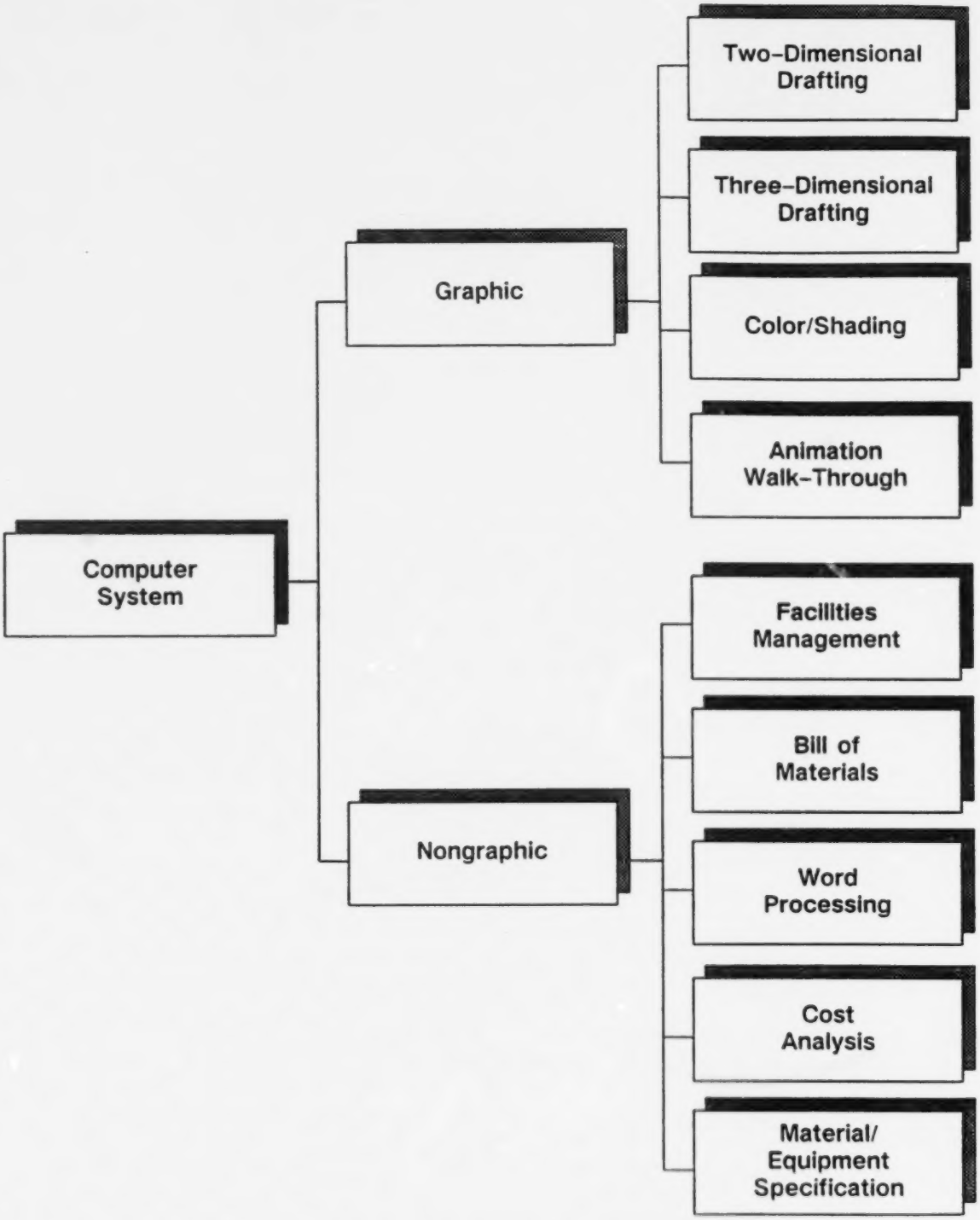

Figure 2 Schematic diagram of an integrated computer-aided design system.

frame model enables a designer to analyze the spatial relationship between a sofa, the walls and the room's traffic path. Three-dimensional software is also effective in converting free-hand sketches to conventional drawings. Once a desired design solution is created and plotted with three-dimensional software, a color rendering can be completed at a fraction of the cost. This application is more effective than the traditional method when presenting and explaining proposed design solutions to clients because three-dimensional software allows a designer to create several solutions quickly.

Three-dimensional computer modeling increases the client's understanding of spatial relationships and color through manipulation of objects. A designer can select and deselect objects on the screen, move them to new locations or resize and rotate them (5). With solid models the designer can use four directional light sources to achieve different color-shading effects. A designer can set the light source for intensity and direction. Furthermore, an object's hue, value, and intensity can also be altered to analyze color relationships and the effects of simultaneous contrast.

Perspective animation allows a designer and client to approach a building from any direction, pass through the doors and look around in a realistic spatial sequence. Scale and proportion can be perceived from various eye-level views giving an individual the ability to mentally rotate objects and judge sizes and distances.

Animation creates a realistic visual presentation of the proposed design which improves the individual spatial cognitive process.

Nongraphic Applications

A very successful application of CADD technology in the design process is facilities management (6). Designers require information about a building to make planning decisions. Considering the complexity of any facility it is difficult to obtain, manage, and track the facility adequately. For example, it is common for a business to not know how much square footage it has or how many work stations exist in various departments. A CADD system can retrieve and maintain accurate facility data. CADD drawings become the designer's data base to aid in the decision making process. There are various features of a CADD system that are critical to successful facilities management including:

. Space management;

. Report writing;

. Chart generation;

. Specification and estimating.

Space management analysis involves utilizing data about square footage, people, equipment, and activities to determine the spatial requirements (7). CADD allows the accurate and efficient manipulation of these large volumes of data. In estimating space requirements for a facility, automatic area calculation is a CADD feature that many designers have found useful. For example, when

given the number of desks in the proposed facility and several other parameters, a CADD system can generate a listing of required spaces, together with cost and area summary data.

A CADD system can also report where an object is located in the facility. This feature is called "positional properties". When a desk is moved on the monitor the system can automatically report its location. If the desk is moved to a new space, its new location is reported by the CADD system. Area calculation and positional property features compliment each other in space planning. In the design process of a project, if the walls are moved, the adjusted area is updated automatically and, if the proposed change includes and excludes objects on the drawing, their status will also be updated. This high degree of data integrity is possible because of CADD's graphic data base structure. A visual inspection of the drawing can still be conducted without the tedious piles of alphanumeric reports.

In office space planning interaction and grouping analysis (8) are also used in determining space requirement needs. An interaction matrix can be used as input to an automated floor plan layout program. An interaction matrix is created for representation of data describing interactions and interrelations between activities or spaces in a proposed or existing building (Figure 3). Interaction matrices can be divided into four basic areas:

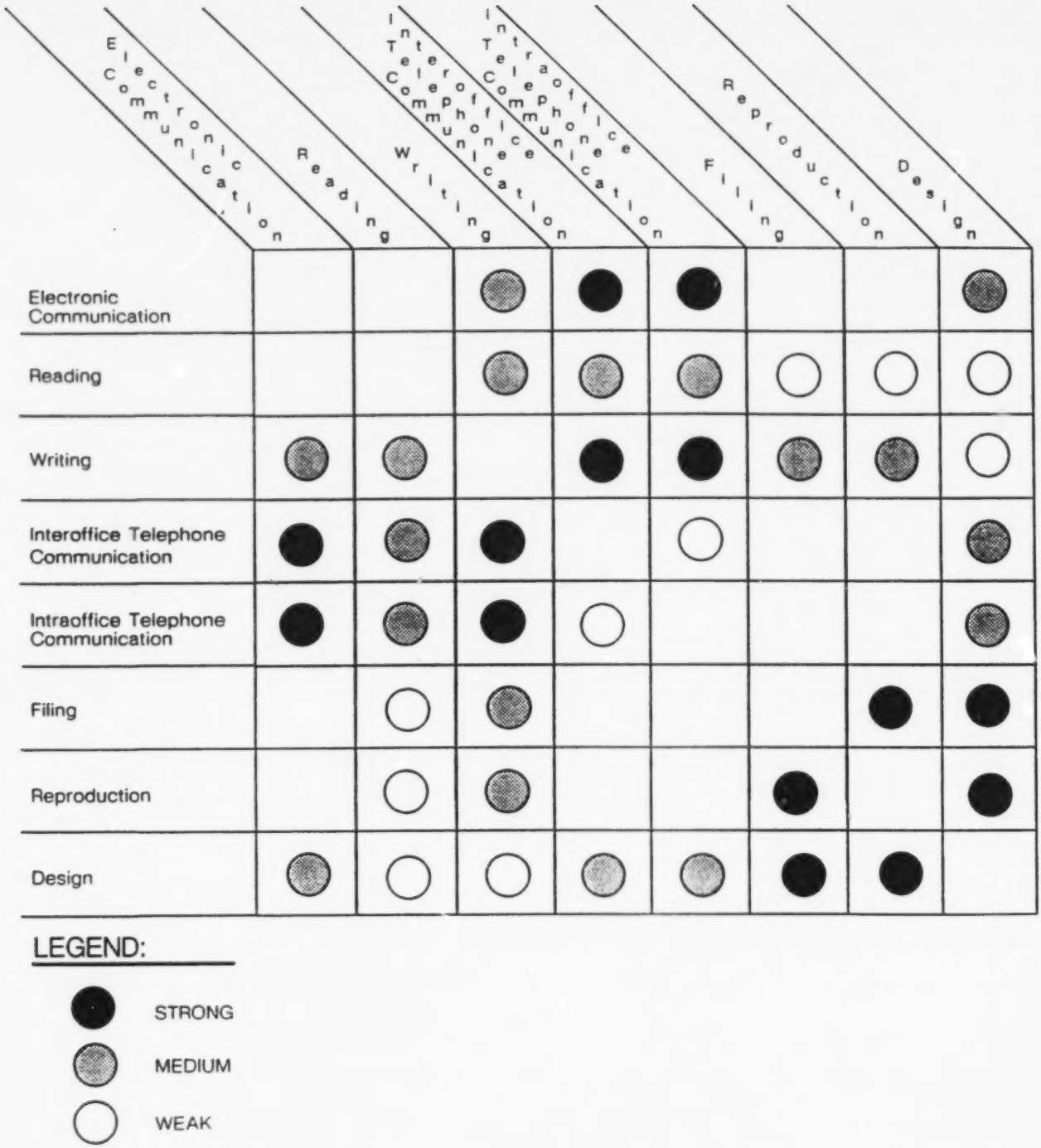

Figure 3 Interaction matrix describing interralations between office activities.

. Adjacency or non adjacency needs of a proposed or existing space;

. Spatial distance requirements of a proposed or existing space;

. Activity relations of a proposed or existing space;

. User traffic flow activity relations of a proposed or existing space.

Interaction matrices contain data representing spatial and functional associations between activities or spaces. Unfortunately, the patterns and large array of numbers are not easily comprehensible. To facilitate comprehension, cluster analysis (a computer-based data analysis technique) was developed for revealing structure in data matrices. Cluster analysis sorts or classifies a set of entities into subsets such that members of a subset are closely related to each other. Activities or spaces in a building defined by an interaction matrix can be functionally grouped by cluster analysis. For example, a designer can obtain data on work station requirements for office employees from a questionnaire survey. Cluster analysis utilizes this data to group employees with similar work station/communication requirements together which then establishes a standardized work station for each group.

In multi-story office buildings a stacking plan is often utilized by a designer in the space analysis process. A stacking plan indicates the assignment of particular spaces to particular

floors. The general objective is to group sets of closely related spaced together on each level and to plan interrelated groupings of spaces on closely adjacent floors. Typical output from a stacking plan program would include the amount of square footage on a given floor and the amount of square footage available on the floor. The output would also display the amount of square footage in the various departments on a given floor.

Based upon the cluster analysis, an algorithm was developed (9) by The Computer-Aided Design Group. The algorithm can automatically generate space layout solutions. The final layout is "scored" by the system so that the relative efficiency of a solution may be compared and analyzed against alternatives. The score is derived by multiplying the distance between related activities and their interaction value.

Another CADD system feature utilized by designers in facility space planning is report generation (10). This software produces user definable reports from the graphic data base. Any graphic element on a drawing can have non-graphic information attached to it. Therefore, if a designer needs to know how many stackable side chairs exist in the accounting department, the software will report the number. Automatic material/equipment chart generation can also be produced to aid the designer with specification and cost estimating. For product specification, systems such as Anderson Window's CADD package allows a designer to enter performance

criteria for a building and then the system will match the required performance to its available products. These features are extremely useful in large commercial projects where specifying and pricing is a very tedious and time consuming endeavor. Specification writing can be expensive full-time employee positions for many design firms. Computer-assisted specification software can eliminate the expense of specification writers, reduce errors, and improve productivity.

Data can also be processed from system to system within a design firm. Work processing data can easily be included in CADD graphic files as spread sheet information can be filtered into work processing files. To improve the communication process, all in-house stations can be linked together into a Local Area Network (LAN) so that information can be continually and efficiently shared between the various users in a design firm. Through LAN all stations can trade files and access any information. This integration process can be completed with the data base report generator summarizing the project requirements for a client.

Summary and Implications

A computer/CADD system acquisition can become an integral part of a designer's work environment. When the computer is used for input of data at the earliest stages of design, there is no division between design and the technical side of the process. In an integrated computer system installation a multi-task workstation is capable of executing CADD graphic functions as well as utilizing

office automation packages to perform the nongraphic functions. Automation of the procedures in the design process can effectively and efficiently enhance and support the functions required to complete a project.

Interior Designers involved and concerned with the application and use of electronic technology can play a unique role in facilitating the design process. The variable is how well-informed and current interior designers are regarding utilization of computer systems, awareness of communication and interaction processes, familiarity with graphic and non graphic applications, and developing affiliations with professional computer networks. Further education, training and research is needed on the expanding utilization of electronic technology. Educators agree that automated systems instruction is necessary to keep abreast of technological innovations (11). However a void exists in the education and training of CADD equipment and in its application to the design process (12). Industry and education need to develop a symbiotic relationship (13) dedicated to the education of the fundamental and advanced concepts of CADD. Therefore, it is imperative for Home Economists to be recognized as a resource in the continuing education and development of computerized systems in order to more effectively serve the needs of the profession and community.

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